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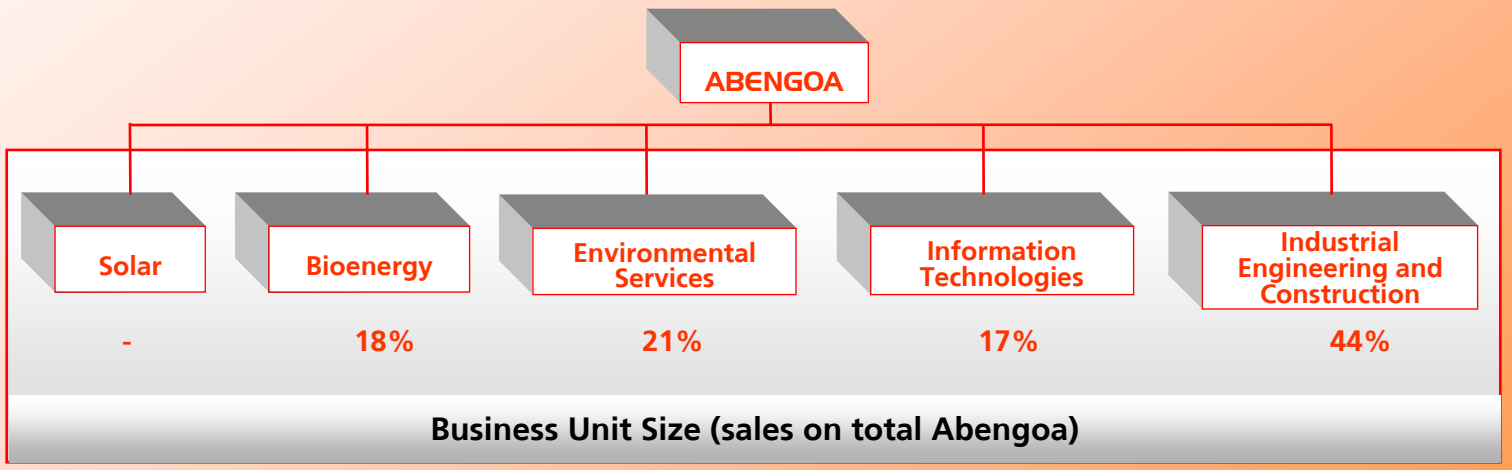
Cellulosic Ethanol: An Abengoa Market Perspective

Mobile Source Technical Review Subcommittee (MSTRS) meeting.
September 19, 2007
Arlington Va.

Science. Solutions. Service.

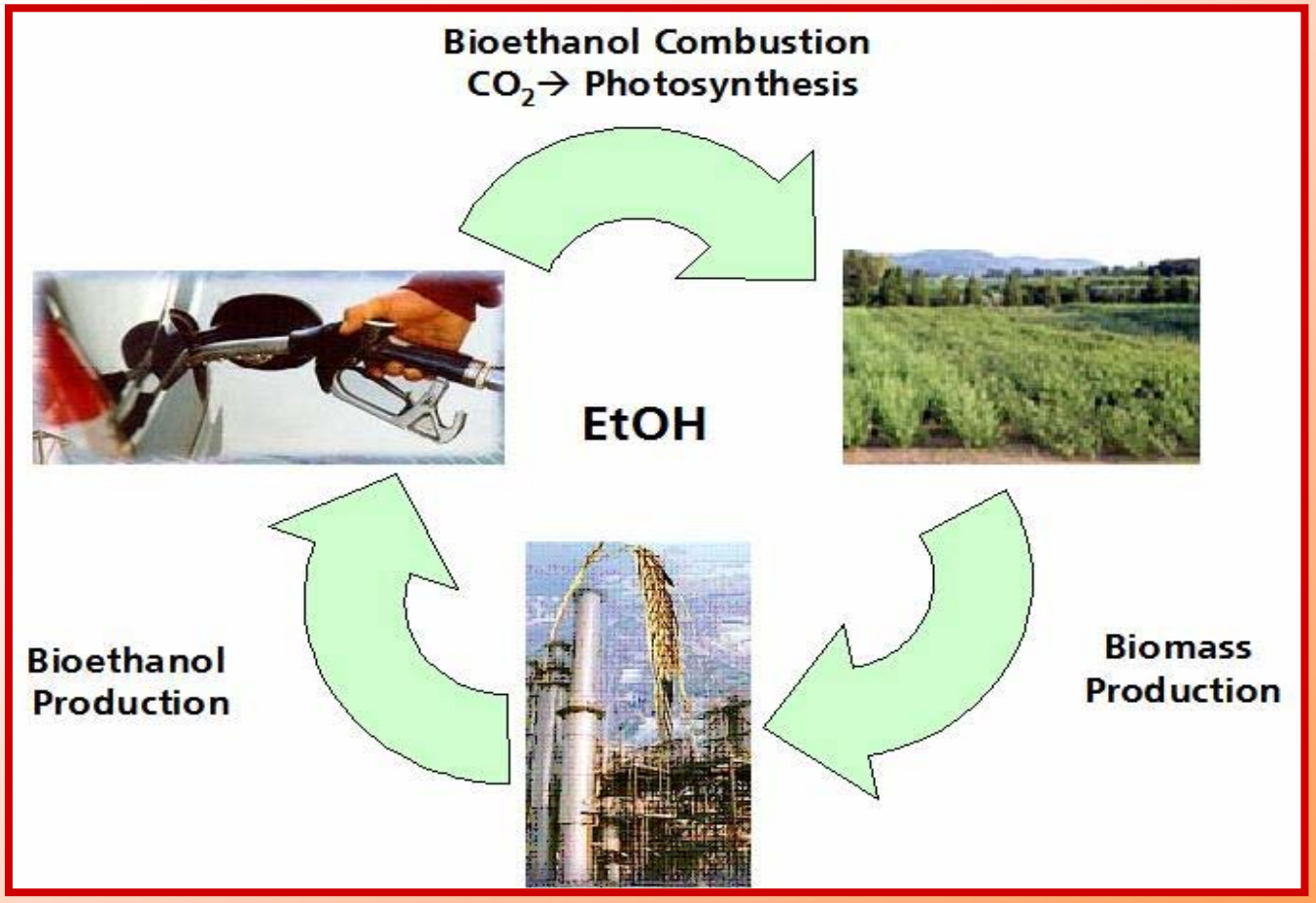
Abengoa is a technological company that applies innovative solutions for sustainable development in the infrastructures, environment and energy sectors. It is present in over 70 countries where it operates through its five Business Units: Solar, Bioenergy, Environmental Services, Information Technology, and Industrial Engineering and Construction.

Abengoa is a listed company in the Madrid Stock Exhange.



Abengoa Bioenergy generates energy from renewables resources, thus contributing to Abengoa´s main focus on sustainable development.

Bioethanol



Ethanol is the most significant alternative to reduce greenhouse gases and reduce our petroleum dependence in the transportation sector

EU and US: Demand and Opportunities

- Biofuel demand depends on
  - Policies
    - Mandates
    - Energy crops incentives
    - R&D and innovation supporting and grants
  - GHG reduction incentives
  - Oil price
  - World stability in oil production regions

- Opportunities
  - EU and US governments are defining and implementing policies to increase the biofuel demand
  - Biofuel demand from lignocellulosic biomass will create great opportunities for those players with technology and capacity available

EU and US: Market Projections

- US and UE markets will be dominated by starch technology up to 2016
- Bioethanol starch markets are presently limited by raw material
  - US: 15 - 24 BGal per year
  - EU: 18 - 20 ML per year
- From 2012 to 2017 biomass plants will start to be operational,
  - Up to 5 BGal/year in US in 2017
  - Up 2 - 3 ML/year in UE in 2017
- Hybrid plants present advantages for early technology deployment
- After 2017 biomass stand alone biomass plants will be viable due to technological and mainly energy crops market development

Additional areas to be taken into account

- China and Brazil will represent great production and marketable areas for biofuels from nonfood raw materials
  - China is expanding quickly the transport sector
  - China oil resources are limited
  - China will use non food starch and lignocellulosic crops for ethanol
  - Sugar cane factories in Brazil generate great amount of bagasse residues
  - The bagasse conversion into ethanol will represent an opportunity for lignocellulosic technology
- India and South Africa are starting to look into ethanol as an option to reduce their energy dependence
- South East Asia could will become a significant production region

Lignocelullosic biomass represents a great opportunity for ABNT

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The Global Ethanol Player

Ravenna, NE * (88 MG)

Lacq * (66 MG)

York, NE (55 MG)

EU (MG)	2006	2007	2008
Production	142	142	208
Construction *	66	66	

Portales, NM (30 MG)

Colwich, KS (25 MG)

Brazil (14.2MG)

Salamanca (53 MG)

Cartagena (39 MG)

La Coruña (50 MG)

US (MG)	2006	2007	2008
Production	110	198	198
Construction*	88		

Abengoa Bioenergy is the main ethanol producer

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DAA – Dedini Açúcar e Álcool Ltda

Company Overview (06/07):	
Total Sugar Cane Crushed	1,865,821 ton
Own Sugar Cane	1,336,606 ton
Third – Party Sugar Cane	529,215 ton

Production:	
Sugar VHP	20,969 ton
White Sugar	170,235 ton
Hydrous Ethanol	25,214 m^3

Co-generation:	
Installed Capacity	7 MW
Generated Energy	33,264 MW
Used Energy	34,626 MW/h

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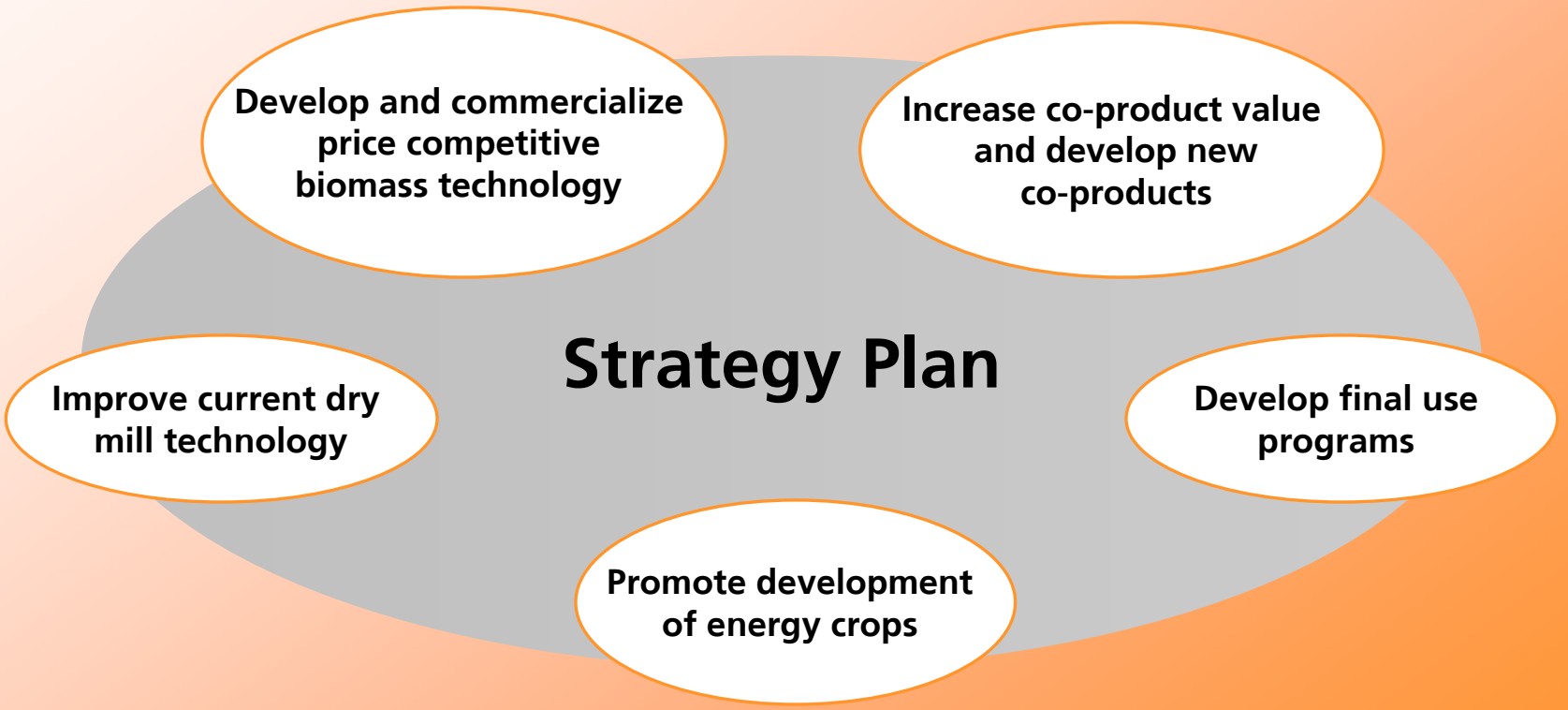
DIC – Dedini S/A Indústria e Comércio

Company Overview (06/07):	
Total Sugar Cane Crushed	2,525,112 ton
Own Sugar Cane	1,494,030 ton
Third – Party Sugar Cane	1,031,082 ton
Production:	
Sugar VHP	103,000 ton
White Sugar	142,469 ton
Anhydrous Ethanol	12,342 m^3
Hydrous Ethanol	38,342 m^3
Co-generation:	
Installed Capacity	10 MW
Generated Energy	47,520 MW
Used Energy	48,882 MW/h

R+D Strategy

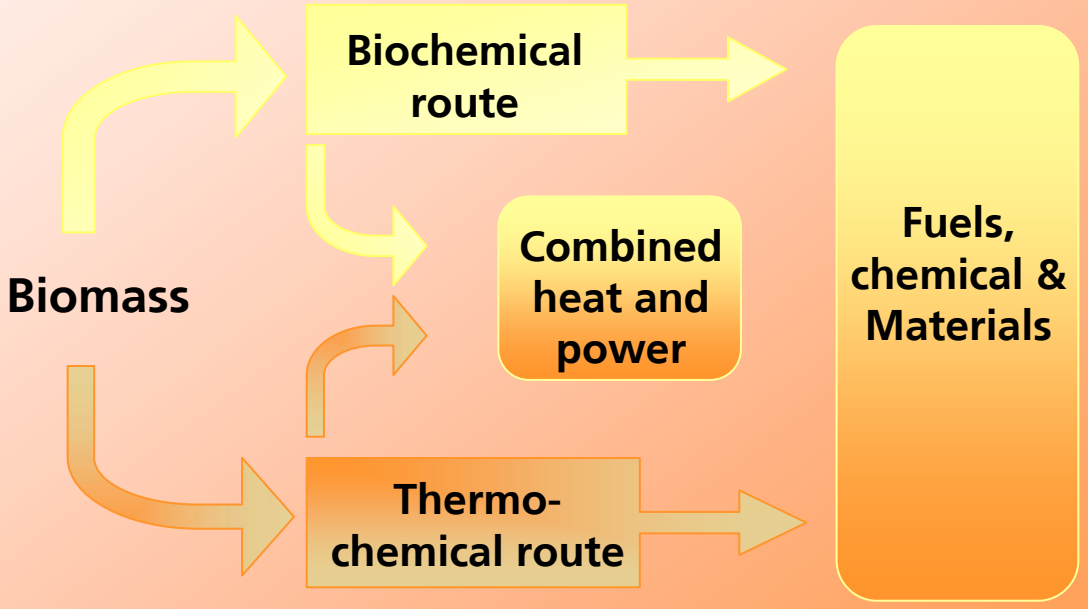
Abengoa Bioenergy carries out its R+D through its subsidiary company ABNT, Inc.

- More than 50 investigators in Europe and US working in R+D
- Use partnerships, JVs and equity investments to develop key production technologies



Biorefinery concept

- Biorefinery is understood as a further stage in the development of technologies based on biomass as feedstock.
- Optimal combination of biological, thermo-chemical, and chemical processes, aimed to produce a complete range of products, using a wide range of feedstock, and getting advantage of synergies between technologies



Feedstocks

Objective

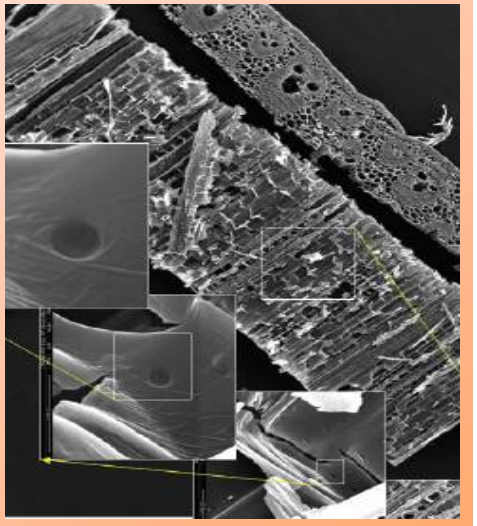
Develop custom made energy crops for the different conversion pathways and for particular regions ensuring sustainability and environmental quality. Main crops characteristics:

- Domestic crops, high starch and biomass yields per acre, stress tolerances, etc..
- Minimum inputs
- Composition to maximize ethanol production
- Ensure sustainability and environmental quality (from…analysis of microbial communities underlying soils… to formulation of management guidelines for biomass removal)

Steps (continue)

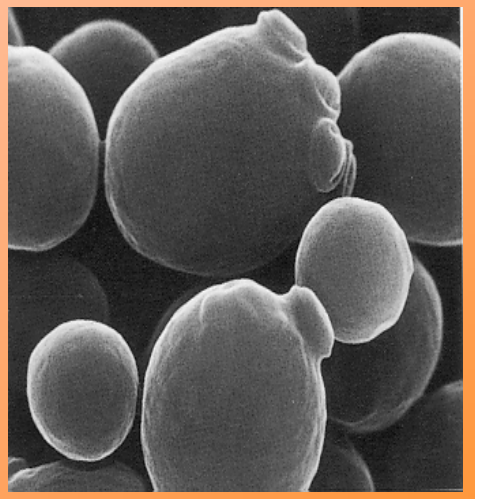
Research in the biological deconstruction of the biomass to produce tailor made enzyme mixes for each specific case:

- Determine fundamental physical and chemical factors in the recalcitrance of lignocellulosic biomass to processing
- Understand cellulase and cellulosome
- Develop new enzymatic systems to reduce thermochemical pretreatment conditions



Advance in the sugar fermentation to ethanol through the engineering of microbial systems to achieve:

- high yield with complete sugar utilization, minimal by- product formation, and minimal loss of carbon into cell mass.
- high final ethanol concentration
- tolerance to inhibitors present in hydrolyzates
- higher overall volumetric productivity, especially under high solids conditions



Current activities

- York Pilot Plant (DOE)
  - Pilot plant: construction completed
  - Startup and operation now
- BCyL biomass plant
  - Economic models completed
  - Construction 75% completed
- Hybrid DOE Project
  - Conceptual engineering completed
  - Contract under negotiation

Pilot scale

↓

Demo scale

↓

Commercial scale

BCyL Biomass Plant

- Capacity : 1.3 MGPY
- Raw material : Wheat and Barley Straw
- Technology : Enzymatic Hydrolysis (glucose)
- Objective : Demonstrate biomass-to-ethanol process technology at commercial scale
- Start-up Operations : Spring 2008

Biomass Demonstration Plant in BCL (Salamanca, Spain)

- Capacity : 1.3 MGPY
- Raw material : Wheat and Barley Straw
- Technology : Enzymatic Hydrolysis (glucose)
- Objective : Demonstrate biomass-to-ethanol process technology at commercial scale
- Start-up Operations : Spring 2008

Residual Starch Pilot Plant in York (NE, US)

- Capacity : 0.45 MGPY
- Raw material : cereal (flexible)
- Technology : Dry-mill cereal technology
- Objective : Achieve higher starch conversion
- Start-up Oper. : Operating

Biomass Pilot Plant in York (NE, US)

- Capacity : 0.02 MGPY
- Raw material : corn stover
- Technology : Enzymatic Hydrolysis (glucose & xylose)
- Objective : Competitive process with grain ethanol
- Start-up Oper. : Now

Biomass gasification and synthesis (BtL) technology – current situation

- Available catalysts are not productive enough to make the process economically feasible.
  - Low conversion per pass
  - Mixed alcohols product with low ethanol selectivity
- Several existing technologists licensing gasification processes for syngas production for further chemical synthesis.
- Catalysts development programs in European research centers, combined with process design and analysis.
- Recently granted by the Spanish government a multiyear program (CENIT) to develop the synthesis catalysts and the process.

Integrated biorefinery co-sponsored by the U.S. DOE

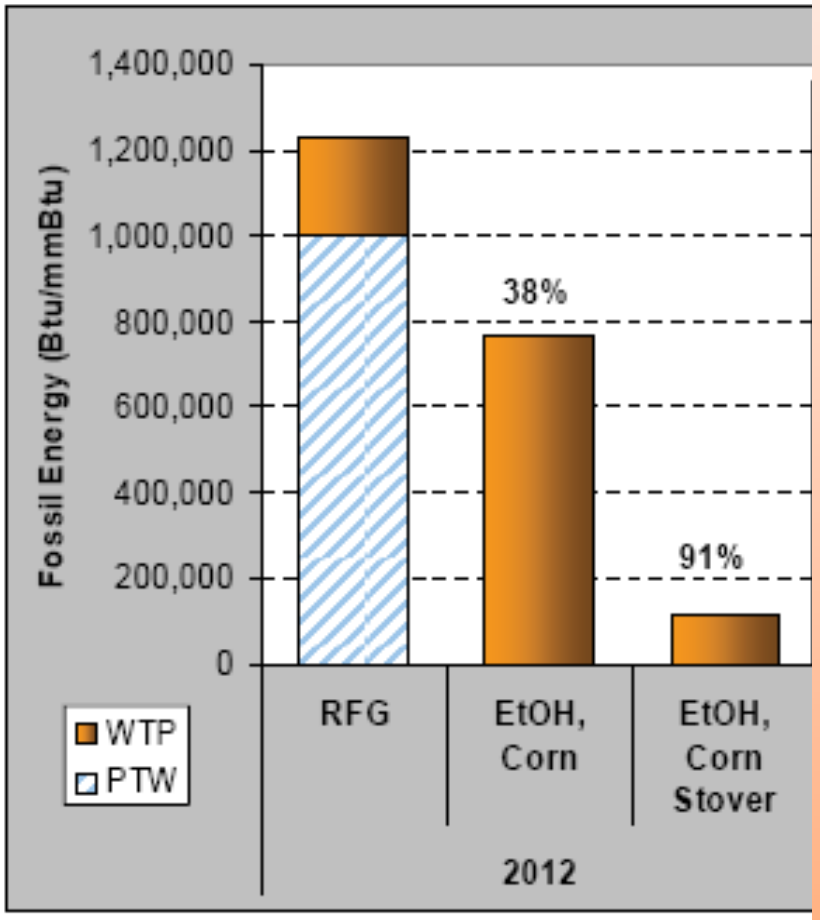
Abengoa's hybrid plant concept

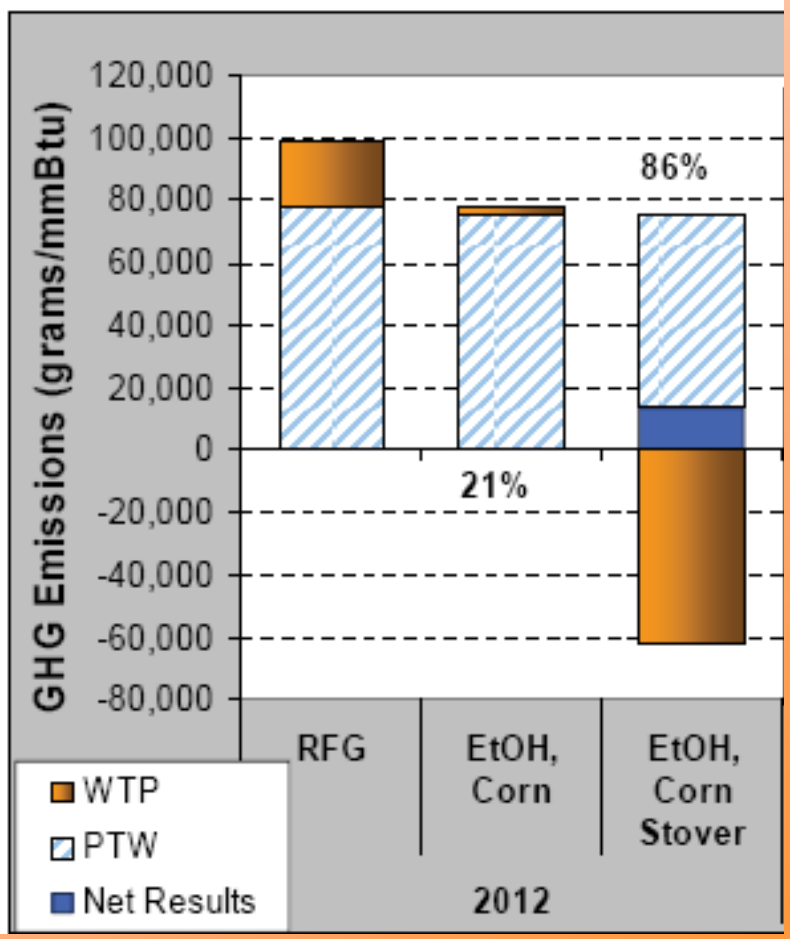
- 35 million bushel grain facility
  - 88 million gallons ethanol
  - 290,000 tons feed co-product
- 245,000 BD metric tons biomass (315,000 short tons-as is)
  - 400 BD metric tons/day
    - 15 million gallons ethanol
  - 300 BD metric tons/day
    - Syngas production
    - 1,597,200 MMBTU (syngas+flue gas)
      - 100% steam needs of biomass processing
      - ~30% steam needs of grain to ethanol processing
    - Syngas can be utilized for production of chemical intermediates
- Located in South West Kansas
- Start-up 2011
- Opportunity to leverage infrastructure at many plant operations

Need to make cellulosic ethanol cost effective/ competitive with grain ethanol

- Process
  - Cost effective enzymes
  - Pentose to ethanol organism (s)
  - Fractionation process
  - Plant design and operational learning curve
- Feedstock
  - High density balers
  - One-pass harvesting systems
  - Storage infrastructure and systems to maintain quality
  - Improved genetics of feedstock varieties
  - Energy efficient harvesting systems
  - Transportation infra-structure and biomass friendly regulations

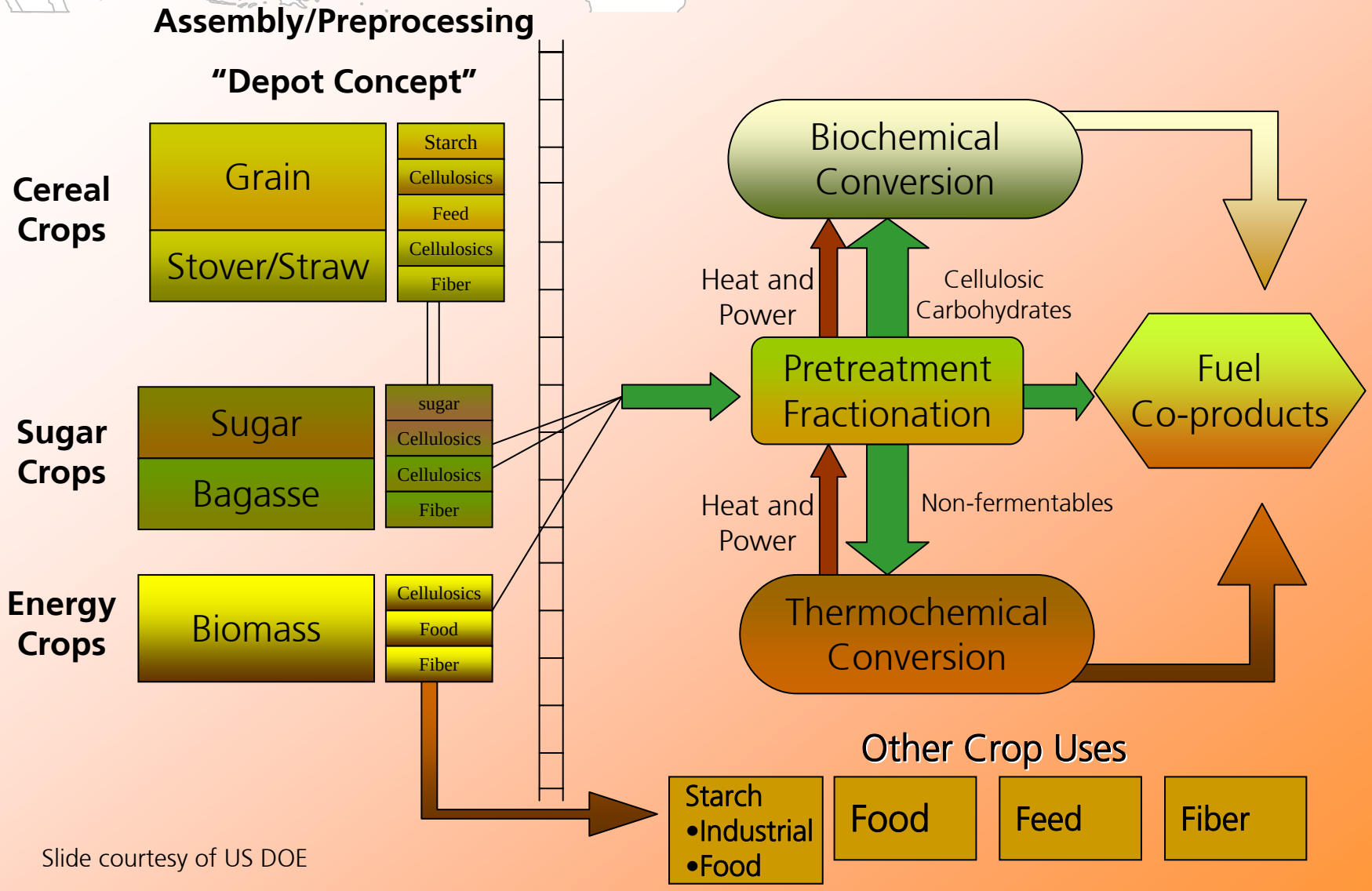
Cellulosic Ethanol Reduces Fossil Energy Use and GHG Emissions





M. Wang, H. Huo, "Fuel Cycle Assessment of Selected Bioethanol Production Pathways in the United States", Report ANL/ESD/06-7, 11/6/06

Future Integrated Biorefinery



Slide courtesy of US DOE

Abengoa Bioenergy

- Leader in production capacity
- Global supplier to oil companies
- Technology innovator and provider to third parties
- Ability to use multiple feedstocks
- World-wide logistics player

Future Market

- Ethanol Competing with gasoline
- Users demanding more ethanol
- Ethanol available at the pump
- Source of energy for under developed countries
- Ethanol flowing to different markets

Bioethanol a sustainable solution to our transportation sector

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Thank you

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